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THE STUDIES OF DIGESTION AND ABSORPTION IN THE CHRONIC INTESTINAL OBSTRUCTION CAUSED BY PERITONEAL ADHESIONS

by

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INTRODCTION

To many surgeons, the occurrences of nutritional disorder in the patients with peritoneal adhesion, particularly those with passage disturbances or those who suffered from recurrent intestinal obstruction due peritoneal adhesion have been well known experiences. Even in those who manifest apparently good general conditions, the constituents of the serum protein often show an abnormal pattern. The present author believes that, from the above described experiences, various degrees of nutritional disorder are involved in those patients with abdominal adhesion and attemptes to clarify pathogenesis of this nutritional disorder and at the same time tries to work out methods of treatment of these patients.

In this study, digestion and absorption capacities of the intestine were investigated in man and animal with or without abdominal adhesions. The digestive and absorptive function of the intestine were also investigated after such operations as blind loop formation, short circuiting side-to-side anastomosis which were performed because of persistent passage disturbances occurring after abdominal operations.

METHODS AND RESULTS

In this investigation, 22 clinical cases of intestinal adhesion and chronic intestinal obstruction and 127 experimental cases of dogs, rabbits and rats were chosen. In rats, the abdominal adhesion was produced by introducing talk powder into the abdominal cavity. Many loops adhesions were produced by mechanically damaging the serosa of the lower portion of the intestine and subsequently applying tincture of iodine and suturing that portion of the intestine in parallel multiple rows. The blind loops were produced by cutting the lower portion of the intestine and reconstructing the continuity by means of side-to-side anastomosis at the part 10 to 20 cm proximal from the oral cut end. The short circuiting side-to-side anastomosis without cutting the intestinal tract was produced at the lower portion of the intestine (Fig. 1). Digestive and absorptive function of the intestine were examined by using rodioisotope technique and ratio method in which chrom oxide was the marker.

1) Digestion and absorption after ingestion of the test meal.

It was found by ratio method that the rate of absorption of carbohydrate was more than 97% in both patients and experimental animals indicating the carbohydrate absorption

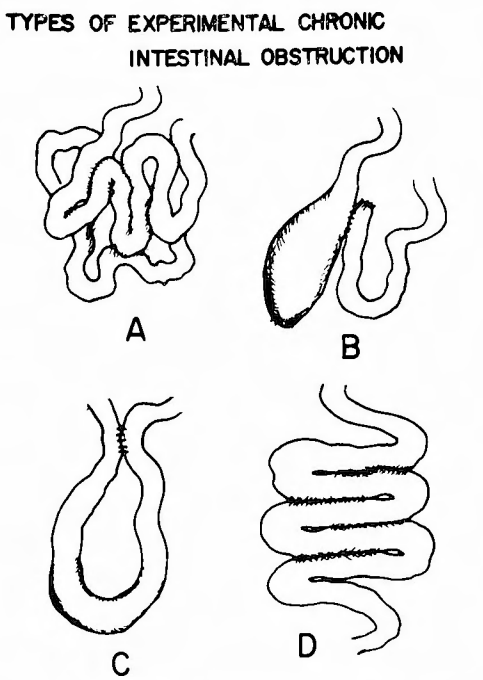


Fig. 1

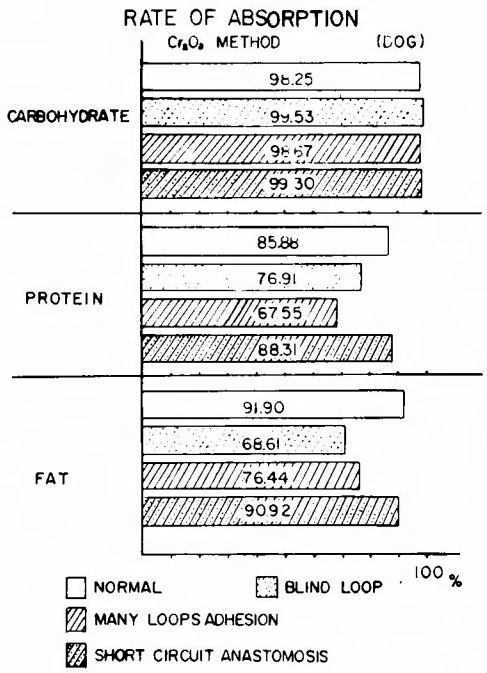


Fig. 2

in these cases was maintined as was in normal. However protein and fat absorption was found to be considerably disturbed both in patients and in animals. The absorption rate of protein was 54 to 97% in human cases and 67 to 88% in dog, while the fat absorption rate was 53 to 90% in clinical cases and 68 to 91% in dog (Fig. 2). The degree of absorptive disturbance was roughly proportional to the degree of passage disturbance and the extent of the hypertrophied distented area of the intestine. In the patents with intestinal adhesion complaining alternative obstipation and diarrhea or soft stool, the absorption of fat and protein was markedly hindered. In the blind loop group and many loops adhesion group, the absorption disturbance was found to be noticeably high. The above described observations were confirmed by measuring the excretion rate of ^{131}I albumin and ^{131}I triolein in stool (Fig. 3). Blood sugar level after the administration of 30 g of glucose to the patients reached the maxium after 30 minutes which was 142 to 152 mg/dl and gradually returned to the normal value. Similar blood sugar fluctuation was also observed in the experimental rabbits.

The radioactivity in peripheral blood after the ingestion of ^{131}I albumin reached the maxium 2 to 3 hours after the administration to the patients. In the dogs with abdominal adhesion, the time required to the maxium counts was prolonged and the activity itself tended to be lower. In rabbits these tendency were more prominent (Fig. 4). When ^{131}I albumin mixed with the gastric and duodenal juice was introduced into the hypertrophied intestinal segment and the corresponding portion of the normal intestine, in the

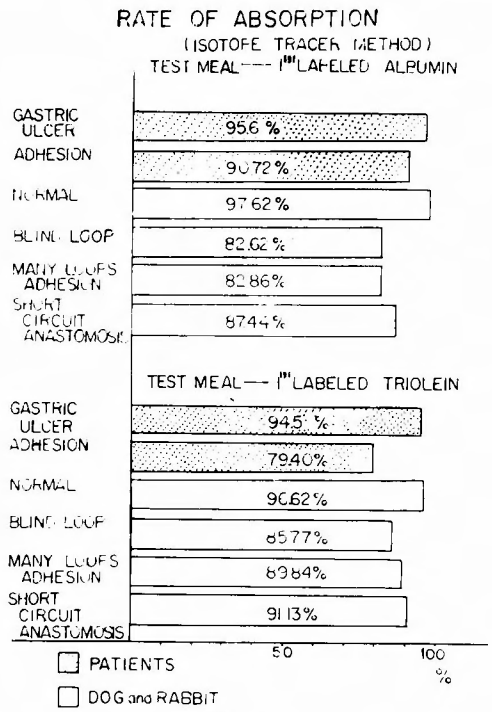


Fig. 3

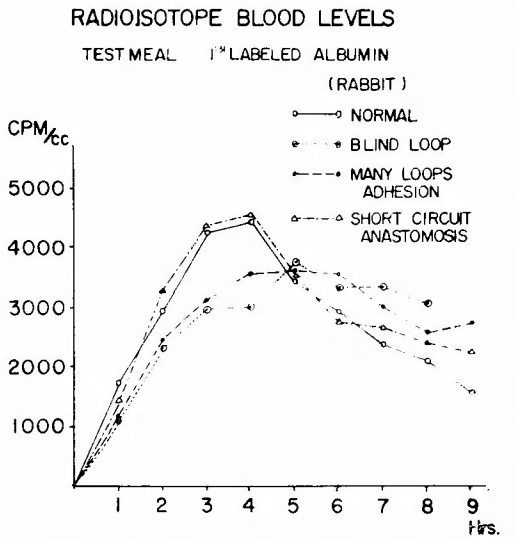
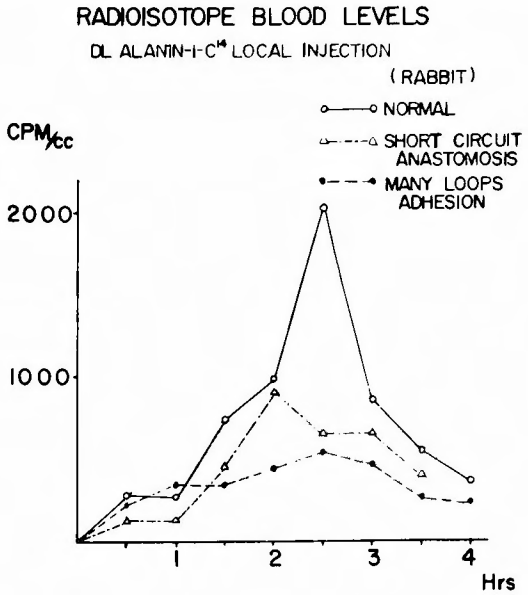


Fig. 4

pathological cases the maximum radioactivities in the blood taken from the mesenteric vein were proved to be lower and it required longer time to disappear from the blood. Similar results were also obtained when DL alanine-1-^{11}C and glycine 1-^{14}C were introduced together with other amino acid solution (Fig. 5). The similar studies with ^{131}I triolein revealed that the maximum counts were recorded four hours after the ingestion in the normal cases. However in the adhesive cases the maximum counts were remar-



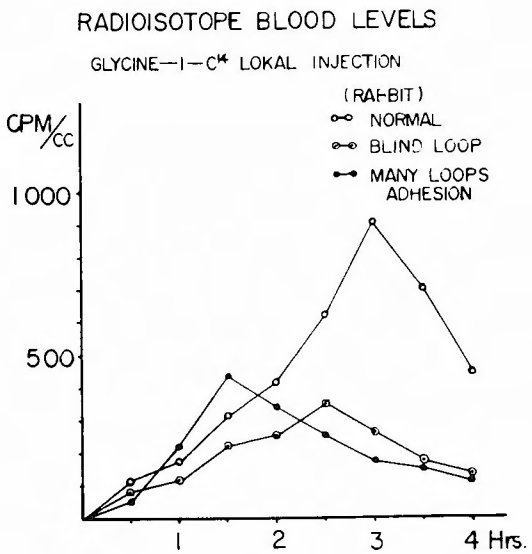


Fig. 5

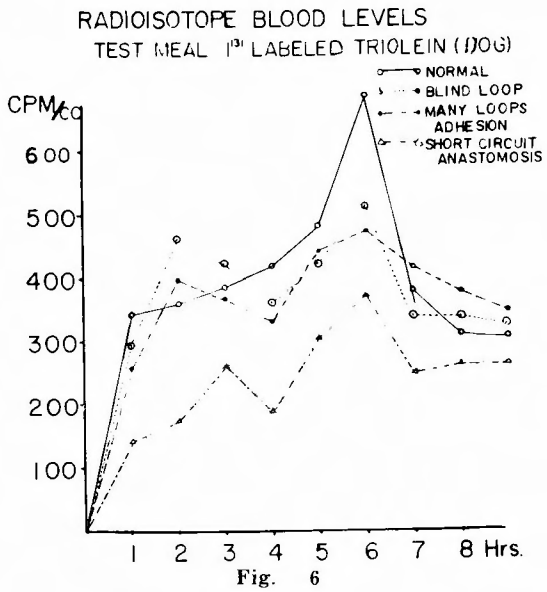


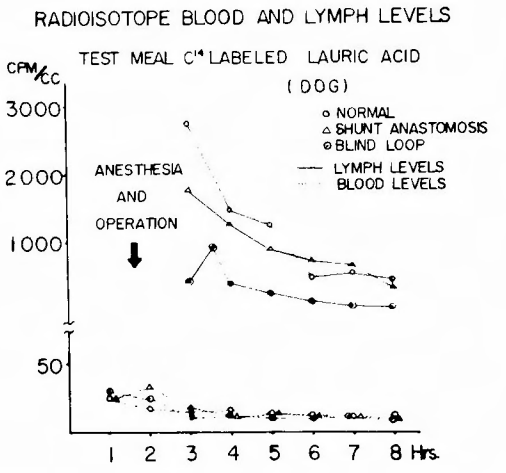
Fig. 6

kably low (4.3 to 5.6 %). Studies with ^{131}I triolein in animals revealed that a considerable disturbance of fat absorption occured when the intestinal adhesion and obstruction were present (Fig. 6).

The examinations of the gastro-intestinal contents of the animals sacrificed 7 hours after the ^{131}I triolein ingestion showed much retentions of the intestinal contents and the total isotope counts in the contents were greater than the normal.

The radioactivity of the portal blood was 1.7 to 2 times as much as those of the peripheral blood, and the activity of the lymph in the thoracic duct was 25 to 45 times as much as those of the peripheral blood.

The absorption of fatty acids from the intestinal canal was investigated by giving lauric acid-1-^{14}C and stearic acid-1-^{14}C together with the test meal and by counting the radioactivity in the peripheral blood. It was found that also when fatty acids was given with the test meal to the experimental dogs with chronic obstruction radioisotope counts in the blood were lower than the normal group. The radioactivities in the lymph obtained from the thoracic duct under anesthesia were also measured. It was detected little radioactivity in the peripheral blood, but higher radioactivity in the lymph. The absorptive



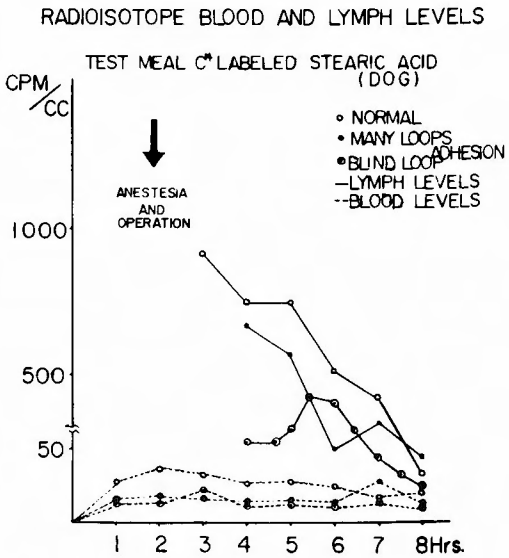


Fig. 7

function of fatty acids in the lymph from the intestine was disturbed in various experimental groups (Fig. 7). As considerable amounts of gastrointestinal contents were found in the digestive canal especially in the blind pouch 8 hrs. after the ingestion of test meal, it was obvious that passage disturbance was present. However the retention of stearic acid and lauric acid as was indicated by the radioactivities was not apparent. All these findings indicate that considerable degree of disturbance in absorptive function was created in the hypertrophied region of the chronic obstructed intestine.

This was also confirmed by measuring the absorption capacity of inorganic ^{32}P ions from the hypertrophic intestine due to adhesion by means of direct intraluminal injection into the rabbit's intestine.

2) Studies of absorption in the isolated intestinal segment

Table. 1

ABSORPTION OF VARIOUS SUBSTANCE
(MODIFED WISEMAN'S METHOD)

SUBSTANCE	INTEST-INE	RATE OF ABSORPTION (%) 30min. LATER	1hr. LATER
I^{131} 50μc	NORMAL	23.6	32.4
	ADHES-ION	8.8	18.6
P^{32} 50μc	NORMAL	22.4	34.6
	ADHES-ION	1.55	6.4
10%GLUCOSE	NORMAL	23.56	46.8
	ADHES-ION	10.56	15.9
I_{131} ALBUMIN 50μc	NORMAL	15.6	17.5
	ADHES-ION	0.8	1.38
I^{131} TRIOLEIN 50μc	NORMAL	17.8	29.8
	ADHES-ION	2.62	4.30
DL-ALANIN-I-C^{14} 10μc	NORNAL	1.72	4.33
	ADHES-ION	1.81	4.4
LAURIC ACID C_{14} 10μc	NORMAL	1.43	2.86
	ADHES-ION	1.47	1.76

In order to avoid undesirable effects from anesthesia, surgical operation and others in the study, the absorptive function of the intestine was studied in the completely isolated and surviving state in the Tyrode solution by means of modified WEISMAN's method. ^{131}I, ^{32}P, 10% glucose, ^{131}I labeled albumin, ^{131}I labeled triolein, DL alanine-1-^{14}C, and lauric acid-1-^{14}C were separately mixed in the intraluminal perfusion fluid and the absorption of these agents from the intestinal wall, as was indicated by the appearance of these material in the outer fluid, was calculated (Tabl. 1).

Albumin and triolein were mixed previously with the gastric and duodenal juice for 30 minutes as before.

In this investigation it was shown that ^{131}I, ^{32}P, 10% glucose, ^{131}I albumin and ^{131}I triolein had lower absorption rates in the multiple adherent intestine as compared with normal. But, with DL alanine-1-^{14}C and lauric acid-1-^{14}C, no apparent difference was noted between normal and pathological intestine.

3) Studies on the passage of the intestinal contents

A certain volume of barium sulfate was given to the patients and experimental animals and the passages of this contrast medium were studied by roentgenography.

In the group with abdominal adhesion or surgically treated intestine, delay of the passage to reach to the coecal region, irregular distribution of the contrast medium in the intestine, abnormal retention shadow, retention of gases in the intestine and enlargement

of the intestine were observed.

In the rabbits, in addition to the above described findings, the retention of the gastric contents was particularly prominent, indicating this retention might be due to passage disturbance at the remote site from the stomach.

4) Studies of activities of the digestive enzymes

The acidities and the activities of lab-ferment (PAUL-COHNHEIM's method), pepsin (EDESTIN method), trypsin (GROSS, FULD & MICHAELIS' method), amylase (WOHLGEMUTH's method) and lipase (CHERRY-CRANDALL's method) were studied with the gastric juice and the pancreatic juice obtained from the patients of the adhesion disease.

Generally the acidity of gastric juice tended to be lower or achylic, and the activities of these enzymes were found to be partially inhibited. However, in the pancreatic juice obtained by the ether induction the enzyme activities remained normal.

5) Studies on the number of bacteria and hydrogen ion concentration of the intestinal contents.

The intestine of the experimental animals in fasted condition was ligated so that the intestine was devided into five equal segments and the intestinal contents of each segments were removed aseptically and diluted 20 × 10^4 times. 0.5 ml. of these dilutions was inoculated on the Endo's media, blood agar media, liver media, ZEISSLER's media and cultivation of aerobic and anaerobic bacteria was attempted by incubating at 37°C for 24-48 hrs. In contrast to the normal intestinal contents, in which only a small number of bacteria were demonstrated, numerous Gram-positive cocci and Gram-negative rods were shown to be present in the surgically treated intestine (Fig. 8).

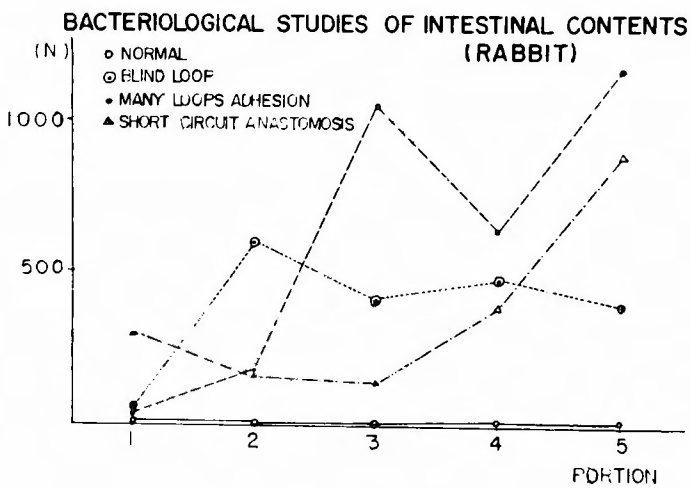


Fig. 8

The pH of the normal intestinal contents inclined to nutral at the lower portion of the intestine both in normal and pathological cases. However only in the blind loop group it always remained alkaline.

6) Analysis of the intestinal gases.

The results of the analysis of the intestinal gases obtained from the adhesive or

Table. 2

COMPOSITION OF INTESTINAL GAS

	NUMBER OF CASE	COMPOSITION OF GAS (VOL %)					
		H_2S	CO_2	O_2	H_2	CH_4	N_2
MIDDLE INTESTINE	7	9.74 (21.2-1.0)	1.61 (3.4-0.5)	8.50 (19.3-5.1)	0.04 (0.1-0)	0.1 (0.2-0)	80.07 (88.65-74.0)
LOWER INTESTINE	11	11.49 (21.6-1.6)	1.32 (2.8-0.09)	1.67 (9.4-0.54)	0.19 (0.6-0)	0.12 (0.5-0)	79.41 (88.56-71.5)
CECUM ASCENDING COLON	6	17.63 (31.4-9.4)	3.12 (11.8-0.6)	3.12 (4.55-0.8)	0.11 (0.4-0)	0.55 (0.5-0.1)	75.04 (81.2-55.4)
TRANSVERSE COLON	7	12.67 (21.1-7.1)	1.27 (3.1-0.15)	6.15 (13.9-0.29)	0.26 (0.6-0.07)	1.09 (5.5-0)	79.83 (88.44-70.5)
SIGMOID COLON	4	16.39 (19.0-13.6)	2.56 (3.4-1.5)	2.66 (4.3-1.4)	0.43 (0.2-0)	0.38 (0.2-0.00)	77.50 (81.1-74.0)

chronic obstruction cases by Haldane's method are summarized in Table (2).

It was shown that volume of H_2S gas was increased in every parts the intestinal tract in the cases of peritoneal adhesion.

7) Histo-pathological studies

From the clinical and experimental cases histo-pathological preparations of the intestine and the liver from the experimental animals were made for microscopical examinations. The microscopical examination of the hypertrophied and dilated intestine showed partial detachments and destructions of the epithelial cells of the mucous membrane, poor stainability and in the extreme cases necrotic or destructive figure of the epithelia were observed (Fig. 9). In some instances direct exposure of the blood vessel to the intestinal lumen was seen. The increase of connective tissue between muscular layers was also noted.

Fig. 9

The vessel walls also underwent partial degeneration as evidenced by the enlargement of endothelial cells, swelling and loosening of vascular walls, congestion of vessels and perivascular edema.

Swelling, loosening and laceration of the elastic fibers were observed in some area (Fig. 10).

In all layers of the intestinal wall, cellular infiltration was observed especially in the submucous coat (Fig. 11).

These findings were most prominent at the hypertrophied dilated segments but also observed at the segments where no apparent hypertrophies were noted.

In the liver, necrosis and vacuolar degeneration of the hepatic ceels, proliferations of the GLISON'S sheath and pseudolobular formation were observed which might account for

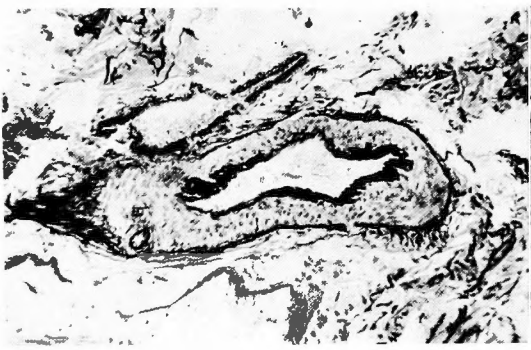


Fig. 10

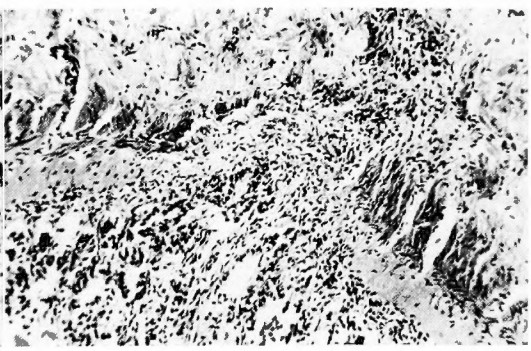


Fig. 11

the disturbed hepatic function often seen in clinical cases.

DISCUSSION

Clinically nutritional disorder of chronic intestinal obstruction due to malignant tumors has been vigorously studied in order to make the postoperative course of the patient smooth and satisfactory.

However little attention has been directed to the patients with abdominal adhesion and no thorough and precise studies on the pathogenesis of such disease appeared to be made.

In this study the author examined the digestive and absorptive capacities of the adhesive intestine by ratio method and isotope tracer method and established that considerable degree of disturbance in the absorption capacity of fat and protein was found to be present both in human cases and in experimental animals.

It appears that nutritional disorder occuring in peritoneal adhesion derived not from the disturbance of digestive capacity but from absorptive capacity of the intestine is caused by hypertrophy and dilation. In these intestinal segments, degenerative and inflammatory reactions were always demonstrated and appeared to be responsible for such disturbance. It should be emphasized that disturbance of the absorptive capacity is not restricted to the site of hypertrophic dilation but neighboring area where macroscopically normal but functionally affected. The author believes this is quite important in analysing clinical cases. The impairment of transport at the remote site from the adhered part implies the involvement of some inhibitary factors other than simple mechanical effect. The bacterial fermentation and autolysis of the intestinal contents also contribute to the accumulation of gases which certainly affects the normal intestinal functions and consequently other vital function of the liver and other organs. As Starzl et al stated, the inhibited absorption of vitamin B_{12} from the intestinal tract due to bacterial toxin may be causing anemia in clinical case.

SUMMARY

Studies on the digestive and absorptive capacity both in the clinical and experimental cases of the chronic intestinal obstruction disclosed that the disturbance of absorptive

capacity of protein and fat was involved.

This disturbance of nutritional absorption was attributed to poor passage of intestinal contents, consequent degenerative and inflammatory changes and poor blood circulation in the intestinal wall.

On the other hand, lowered activities of digestive enzymes, abnormal proliferations of intestinal bacteria, accumlation of toxic metabolites were also presumed to be contributing to the development of the disturbance of hepatic functions in these patients.

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和文抄録

腹膜癒着に基因する慢性イレウスの際における消化吸収機能の検討

徳島大学医学部田北外科学教室（主任　田北周平教授）

西　島　早　見

腹膜癒着による慢性イレウス例および実験的に慢性イレウスを作成（多発性癒着形成群，多列性癒着群，盲嚢形成群，短路吻合群）した動物について，酸化クローム法およびアイソトープ法を中心にして消化吸収機能を検討した結果，含水炭素の消化吸収能は正常例とほぼ同様であつたが，蛋白質や脂肪の消化吸収機能は障害されていることが証明された．これは主として腸内容輸送能の障害，通過遅延にともなう腸壁病変，特に粘膜層の剝離，脱落，炎症性変化，血管壁の病変やうつ血などに基づく吸収障害に起因するものと考えられる．また，慢性イレウスの際には腸内容の停滞による細菌数の増加が著しく，pHの変化，腐敗醱酵に基づく不良中間代謝産物の産生，さらにこれらに関係して肝障害が発生するので，消化管よりの蛋白物質および脂肪の吸収障害はますます助長されるものと考えられる．